DLA Forward Stocking

AFLMA Final Report LY200624000

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May 2007

AIR FORCE LOGISTICS MANAGEMENT AGENCY

MAXWELL AFB, GUNTER ANNEX AL 36114-3236

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From – To)*
		June 2006-May 2007

4. TITLE AND SUBTITLE
DLA Forward Stocking

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Capt John Flory

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)
Air Force Logistics Management Agency
501 Ward St., Maxwell AFB, Gunter Annex, AL 36114-3236

8. PERFORMING ORGANIZATION REPORT NUMBER
LY200624000

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
HQ USAF/A4RM
1030 Air Force Pentagon
Washington DC 20330-1030

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
DLA has proposed to forward stock AF-demanded items in the AOR. Currently DLA forward stores items having four or more demands. This study evaluates the feasibility of forward stocking in terms of DoD savings. The performance of DLA's criteria is evaluated and a new criteria using a cost and demand threshold is proposed. A model is developed to determine the economic feasibility of forward stocking based on realized 5-year annual savings exceeding the increased one-time, investment costs in inventory. Using this model, the performance of both the current DLA and newly developed criteria are evaluated under different storage costs and transportation times.

15. SUBJECT TERMS
Forward Storage, DLA, Optimization, Logistics

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			**Capt John Flory**
U	U	U	**Unlimited**	44	19b. TELEPHONE NUMBER *(Include area code)* (334) 416-4524

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18

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Executive Summary

Background: For items it manages, the Defense Logistics Agency (DLA) directly supplies AF units that are forward in the Area of Responsibility (AOR). Usually DLA-managed items are stored in CONUS and shipped directly to the forward bases. However, DLA has proposed stocking items in theater and shipping the items to the AOR bases from the in-theater forward storage location. Theoretically, forward stocking items should reduce transportation times from the DLA (forward) depot to the forward units. Additionally, the concept is to use less expensive means of transportation from CONUS to the forward DLA depot. A previous AFLMA study LS200520800 addressed forward stocking of relatively expensive AF-managed parts (vice primarily inexpensive DLA-managed items). The study concluded that it was not economically feasible to forward stock the AF-managed parts. Further study was deemed necessary to determine the feasibility of forward stocking predominantly inexpensive DLA-managed parts.

Problem Statement: DLA currently decides whether to forward stock items based solely on a demand threshold (4 or more demands in a year). Incorrect stocking decisions could result in increased inventory or increased transportation costs that are ultimately incurred by the AF. This study seeks to evaluate if forward stocking is cost beneficial and, if appropriate, develop new criteria to determine which items, if any, are cost and mission effective to forward stock.

Objectives: The objectives of this study are to:

1. Determine whether it is feasible and, if so, under what conditions it is feasible for DLA to forward stock AF-demanded items.

2. Evaluate and, if necessary, develop better criteria to select items to forward stock.

Methodology: A model of forward stocking was developed to determine whether an item is economically feasible to forward stock. Then a heuristic was developed that combined cost criteria with demand criteria. The performance of this heuristic was evaluated using demand data for the Middle Eastern AOR. A sensitivity analysis was conducted for varying ship times, and savings is also evaluated based on changing reorder point levels.

Conclusions:

1. Current DLA forward stocking decision criteria ($\geq$ 4 demands) only selects 10% of the items used in the AOR but ***increases cost by $675K*** over a 5-year period.

2. Using the following criteria to forward stock items reduces cost by $955K over a 5-year period and stocks 20% (5K) of items used in the AOR:

$$\text{Stock if} \quad \begin{cases} \text{Cost} < \$50 \\ \text{Demands} \geq 2 \end{cases}$$

3. It is economical to stock at the Defense Distribution Depot Kuwait (DDKS) 19% (3K) of the inexpensive, DLA- managed items that are not currently stocked at the using bases due to storage limitations. If storage space becomes available for all these items, cost is reduced by $747K over a 5-year period.

4. Forward stocking may be beneficial to offset the availability of storage space at the AOR bases. However, to realize maximum benefits, pipeline times for the DDKS to the AF-base must decrease and better in transit visibility is needed.

   - For items with insufficient storage to stock at the using base, if ship time from DDKS to the forward bases can be lowered to 5 days, the economical cost threshold would remain at $50, stock 19% of items and save an additional $85K ($832K-$747K) over a 5-year period

     -- This would also reduce SBSS levels at the using Air bases by $1.5M

Recommendations:

1. Apply the proposed criteria to determine what items to forward stock at DDKS. (OPR: HQ DLA J-3734)

2. If pipeline times can be reduced, DLA should stock items at the DDKS that have insufficient storage at the using base. (OPR: HQ DLA J-3734)

3. Develop a process to update SBSS demand levels with forward DLA stocking order and ship time (O&ST). (OPR: HQ DLA J-3734 and MAF and CAF LSCs)

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Chapter 1

Introduction

Background

For items it manages, the Defense Logistics Agency (DLA) directly supplies AF units that are forward in the Area of Responsibility (AOR). Usually DLA-managed items are stored in CONUS and shipped directly to the forward bases. However, DLA has proposed selectively stocking items in theater and shipping the items to the AOR bases from the forward storage location. Theoretically, forward stocking items should reduce transportation times from the DLA (forward) depot to the forward units. Additionally, the concept is to use less expensive means of transportation from CONUS to the forward DLA depot.

Current DLA business rules select any item with 4 or more demands in a year as a candidate for forward stocking. AF/A4RM tasked us to evaluate the feasibility of DLA forward stocking, to examine the cost-effectiveness of the current DLA criterion and, if appropriate, develop a new set of criteria for forward stocking items. The goal is to reduce costs incurred by the DoD while providing equal or better than current (direct ship from CONUS) levels of support. A previous AFLMA study LS200520800 addressed forward stocking of relatively expensive AF-managed parts (vice primarily inexpensive DLA-managed items). The study concluded that it was not economically feasible to forward stock the AF-managed parts. Further study was deemed necessary to determine the feasibility of forward stocking relatively inexpensive DLA-managed parts.

Problem Statement

DLA currently decides whether to forward stock items based on a demand threshold (4 or more demands in a year). Incorrect stocking decisions could result in increased inventory or increased transportation costs that are ultimately incurred by the AF. This study seeks to evaluate if forward stocking is cost beneficial and, if appropriate, develop new criteria to determine which items, if any, are cost and mission effective to forward stock.

Objectives

1. Determine whether it is feasible and, if so, under what conditions it is feasible for DLA to forward stock AF-demanded items

3. Evaluate and, if necessary, develop better criteria to select items to forward stock

Scope

This study addresses DLA managed items. Although the data used in this study was strictly from the Middle Eastern AOR, the *methodology* employed is applicable to any proposed forward stockage depot. The general form of the criteria is applicable to other AORs; however, the specific values of the cost and demand criteria will vary.

Assumptions

In the analysis we modeled the current inventory flow in the AOR. The model assumed:

1. Theater-wide demand for an item is constant. To determine inventory and transportation cost, we used historical demand to forecast future demand. As is the case with most inventory models, we assumed constant (no trends) demand.

2. The model requisitioned the steady state demanded. Once the required (new level of) safety stock is on-hand, the model replenishes the demand quantity. Hence, there may be a one-time inventory investment in safety stock and then an annual cost to requisition to exactly satisfy demand.

3. Actual past pipeline times reflect future times. The model used historical order and ship time from CONUS to the AOR base and from the DLA forward depot to the forward base. We conducted a sensitivity analysis of these times.

4. Inventory storage costs at Defense Distribution Depot Kuwait (DDKS) are subsumed in the DLA surcharge. DLA currently has a surplus of storage space, so it is likely that an additional cost for inventory storage is irrelevant. In case this assumption isn't valid, a sensitivity analysis is conducted on inventory storage costs in Appendix B.

Limitations

It was not possible to obtain data from DLA on the transportation times and costs it incurs. Instead the data had to be estimated based on Standard Base Supply System (SBSS) and TRANSCOM data. This is discussed in Chapter 2. A sensitivity analysis was performed in which transportation costs and times are varied to observe the performance of the criteria.

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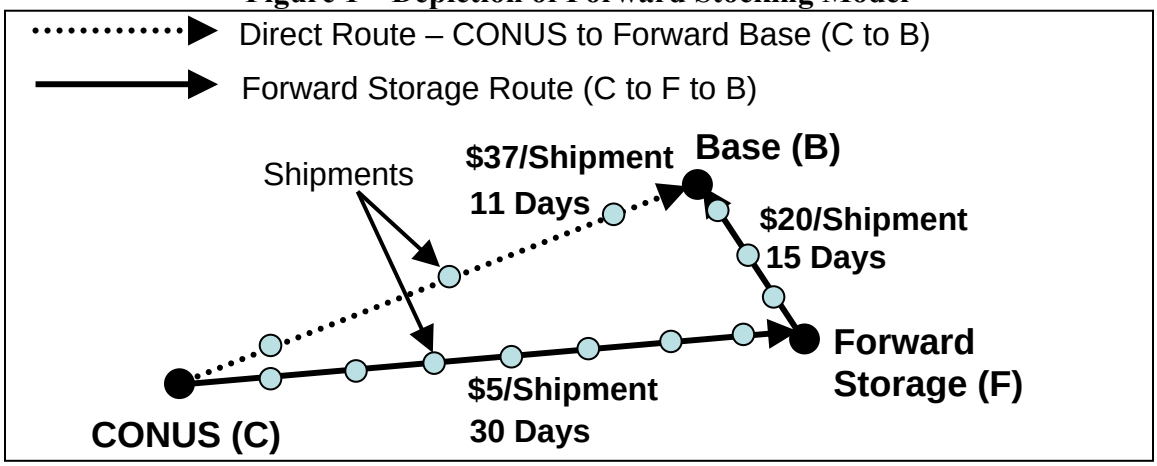
Chapter 2

Research and Analysis

Methodology

We modeled direct shipping from CONUS to the base and for shipping to a forward stocking location and then to the base. The following diagram depicts the structure of the model:

Figure 1—Depiction of Forward Stocking Model



The model computes the inventory pipeline and transportation costs for each item from CONUS either direct to the air base or to forward storage and then to the forward base. The model was written in Visual Basic and the code is in Appendix D. Inputs to the model are the transportation costs and times of each route along with the item's cost and daily demand rate. The model computes the breakeven point, that is, the amount of time required for the lower transportation costs associated with forward stocking to make up for the increased pipeline inventory. Also computed is the resulting savings or cost over a 5-year period. Premium and routine transportation costs were based on AFMAN 23-110, Chapter 19. Transportation times were determined as follows:

1. DLA shipping time data for forward stocking was not available. We used actual SBSS data for order and ship time (O&ST) for the CONUS to forward base shipping times. The SBSS O&ST (or the routing identified record) used for demand leveling averaged 11 days. We validated the O&ST using a year's receipt data in the AOR.

2. There was no SBSS data for ship times from CONUS to DDKS. TRANSCOM reported that average shipping time from CONUS to DDKS was 37 days. However, this may be high because the TRANSCOM data includes items not issued off-the-shelf as well as other items (e.g., hazardous cargo, non-supply items, and spurious

data). We assumed (very conservatively) a 30-day (non-premium) ship time. We conducted sensitivity analysis on the shipment times from CONUS to and from DDKS to the forward bases.

3. There are little or no AF items stocked at DDKS currently, so there is no SBSS ship time data to use to validate the TRANSCOM times. TRANSCOM reported time from DDKS to forward bases (all services) averaged 15 days. Since all shipments from DDKS are off-the-shelf, there is no basis to question the 15-day time, and we accepted the TRANSCOM 15 days as the DDKS-to-forward-base pipeline time.

Items traveling directly use faster modes of transportation such as airlift or commercial carriers; therefore, the pipeline time is shorter, and there is less inventory in the pipeline (see Figure 1). On the other hand, items forward stored will travel to the forward storage location via less expensive transportation modes (i.e. cargo ships) and from forward storage to the base via ground convoys or intra-theater airlift. These slower but less expensive modes of transportation increase the time and therefore may require more pipeline inventory. Additionally, lower pipeline times mean less safety level inventory is required for the direct route; whereas, more safety level inventory is required for the forward storage route. Table 1 summarizes the cost and shipment times.

Table 1—Direct vs. Forward Storage: Inventory Levels and Transportation Modes

	Direct Route	**Forward Storage Route**
Mode(s) of Transport	More Expensive/Faster	Less Expensive/Slower
Pipeline Inventory	Less	More
Safety Level Inventory	Less	More

The choice of route—direct or via forward storage—for a particular item should be based on which is economically cost beneficial. The costs associated with using a route consist of one-time, inventory investment costs and annual transportation costs. Upon choosing a route, the pipeline must be filled with inventory (goods in transit), and a safety level inventory must be established. This may cause a one-time increase in inventory. Pipeline inventory is part of the Reorder Point (ROP) and is computed as the number of items in transit within each route. Safety level inventory is also part of the ROP. The ROP is each route's respective pipeline time plus a level of stock to protect against demand and pipeline variability. Once the pipeline safety level inventories are set, they remain constant (assuming shipping times and demand levels are static) over time. Thus, there may be a one-time cost to invest in the new ROP level. Each year the route is used, shipping costs are incurred for each replenishment order. The Economic Order Quantity (EOQ) determines the annual shipment cost. For example, if annual demand is 100 and the order quantity is 10, there will be 10 shipments a year.

Forward stocking may require higher quantities of pipeline and safety level inventory; therefore, it may have higher one-time, investment costs than the direct route. However, because forward stocking relies on less expensive transportation, its annual costs will be lower. (Note that the costs associated with purchasing inventory for demand will be

identical for each route since, in the long-run, shipments exactly satisfy demand.) Costs are summarized as follows:

Table 2—Comparison of Inventory Investments and Annual Costs

	Direct Route	**Forward Storage Route**
Investment Costs	**Lower Investment**	**Higher Investment**
Pipeline Inventory	*Lower*	*Higher*
Safety Level Inventory	*Lower*	*Higher*
Annual Costs	**Higher Cost/Year**	**Lower Cost/Year**
Shipping	*Higher*	*Lower*
Purchase Demand Inventory	*Equal*	*Equal*

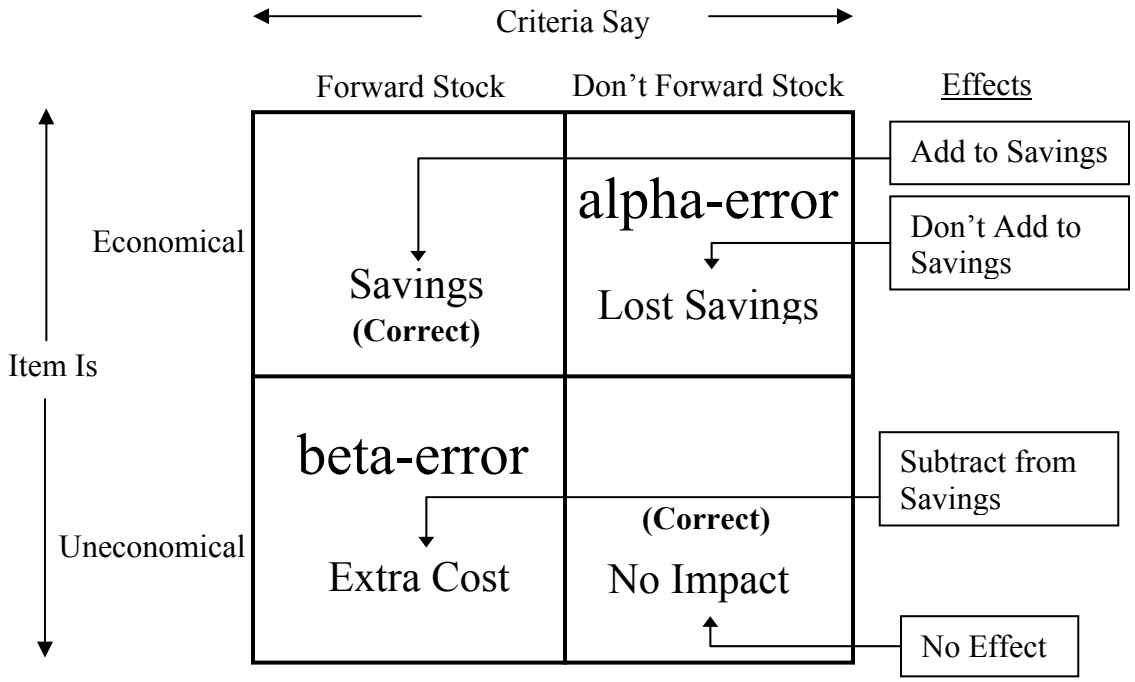
Given a long-enough time-horizon, any item can be economical to forward stock since the accumulated savings from lower, annual costs will eventually break even with and then exceed the one-time investment costs. Forward stocking is considered cost beneficial if the breakeven occurs in an acceptable amount of time. In accordance with AFMAN 23-110, items are considered cost beneficial if the breakeven time is five years or less. Therefore, if the cumulative annual cost savings of forward stocking an item matches the increase in investment costs in less than five years, the item is considered economically feasible to forward stock.

Measuring the Performance of a Stockage Criteria

We seek to develop criteria that identify items to forward stock that are economical to forward stock. More specifically, the rule should not be one that stocks the highest percentage of items correctly but one that selects items resulting in the greatest cost benefit. A set of criteria could potentially classify more items correctly than another but ultimately result in more expense because the mistakes it makes are costlier. Savings result when an economic item is forward stocked. It is the amount of money saved beyond the breakeven point over a five-year period. Likewise, extra expense is incurred when an uneconomical item is forward stocked. The expense is the amount of money by which the savings fall short of the breakeven point over a five-year period.

For a particular item and criteria, there are four possible outcomes (refer to Figure 2). The first outcome is that the item is "economical" and forward stocked. This is a correct decision resulting in savings. The second outcome is that the item is economical but not forward stocked. This is called alpha-error and the potential savings from forward stocking the item is lost. Next, an uneconomical item can be forward stocked resulting in beta-error and extra expense. Finally, an uneconomical item that is correctly not forward stocked has no effect on savings or expense. We seek a rule that minimizes incorrect decisions (alpha and beta error). However, beta error actually incurs costs (as opposed to a lost opportunity for savings), so it is considered the more egregious error.

Figure 2—Performance Outcomes



We built a model that *optimally decides* what items to forward stock and computes the costs and savings. We then use the optimal model to develop easier-to-use rules of thumb to select what items to forward stock. Using the model to determine the costs, it is now possible to measure the current DLA rule and develop and evaluate other rules of thumb. In the next section, several rules are examined.

Proposed Criteria

In this section, simple criteria are proposed to determine whether an item should be forward stocked. We then compare the results to the optimal rule. Recall that DLA forward stocks an item if it has four or more demands in a year.

The following form for the criteria is proposed:

$$\text{Forward stock if} \quad \begin{cases} \text{Unit Price} < \text{Some Threshold} & \text{-and-} \\ \text{Demand} \geq \text{Some Threshold} \end{cases}$$

Examination of the optimal rule (breakeven formula) indicates if one of two items with equal demand rates is economical to forward stock, the other item will also be economical if its cost is less than or equal to that of the first item. This is the rationale for the cost threshold. For items having equal costs but different demand rates, the

implications of one item being economical are not so straightforward. However, DLA wants to only forward stock high-demand items rather than selecting items that have very infrequent or one-time demands. Therefore, DLA's current criteria ($\geq$ 4 demands/year[1]) seeks to only stock items that are likely to have future demands in the theater.

We seek a simple cost criteria threshold that results in reasonable decisions—forward stocking economical items and not forward stocking those that are not economical. Using actual SBSS AOR demand and cost data from Jan 05 to Jul 06, the forward stocking model which we developed computes the breakeven time and designates items as either economical or uneconomical to forward stock. Next, the criteria are applied which forward stocks items based on the cost and demand thresholds. Finally, performance is evaluated by comparing the simple forward stocking rule decisions against the correct decision for each item based on its breakeven time.

DLA views theater-wide demand levels; that is, aggregate demand from a number of bases in the theater. For this study, the Middle Eastern theater was used. Although actual DLA data indicating DLA levels were not available, three representative aggregate pipeline inventory levels were constructed. The first combined demands from 5 Middle Eastern bases: Al Dhafra, Ali Al Salem, Al Udeid, Baghram, and Balad and represented combined Middle Eastern theater demands; the second consisted of items not currently forward stocked due to insufficient storage space; and the third dataset consisted of items currently forward stocked. In summary, the process is as follows for a particular dataset:

1. Select cost and demand thresholds

2. Compute whether each item is economically feasible to forward stock with cost and demand threshold.

3. Compare simple rule performance to optimal performance.

4. Evaluate performance

Analysis

Analysis was conducted on the combined Middle Eastern theater demands, the items currently not forward stocked due to insufficient storage space, and items that are currently forward stocked. Several different set of criteria are applied to the demand data, and their performance is discussed. The pipeline times from CONUS to the base (days) were extracted from the AOR bases' SBSS routing identifier record. The CONUS to forward storage times were estimated derived from analysis of TRANSCOM data. The forward storage to base times were derived from TRANSCOM provided pipeline performance based on shipment time from the US Army Material Command. Sensitivity

[1] Noble, Jackie. *Adventures With the DDC-Building a Depot*; *The Magnificent Seven Make DDC History*. DDC News, Winter 2004.

analysis was also conducted with varied pipeline times (see discussion below and Appendix B. Transportation costs based on AFMAN 23-110, chapter 19 are as follows:

Table 3—Pipeline Costs and Times

Route	Cost ($/shipment)	Time (days)
CONUS-Base (Direct)	37	11
CONUS-Forward Storage	5	30
Forward Storage-Base	20	15

Combined Middle Eastern Theater Demands

The combined demands consisted of 24,589 items at Al Dharfa, Ali Al Salem, Al Udeid, Baghram, and Balad as of 30 Jun 06. The performance of the current DLA criterion is:

Table 4—DLA Criterion Performance: Demands ≥ 4/year

	Forward Stocked	Not Forward Stocked
Economical	1,682 ($723K)	9,920 (-$688K)
Not Economical	801 (-$1.388M)	12,186

TOTAL 5-YEAR NET LOSS: -$675K

The DLA criteria is to forward stock all items that had 4 or more demands in the AOR. It would forward stock 2,483 (1,682+801) items (10% of the 24,589). ***The current DLA criteria results in a net loss of approximately $675K ($723K-$1.388M) over a 5-year period due to excessive pipeline inventory costs.*** (Note that the -$688K is an opportunity cost and does not actually incur a monetary expenditure. Thus, it does not factor into the net savings or loss.) This is evident by the 801 items forward stocked that are not economical to stock (beta-error) and the associated cost of -$1.40M that overwhelms the transportation savings of $723K. The total net loss of $675K is over a 5-year period.

Now consider the addition of a cost criterion with DLA's demand criterion. The best criteria are:

Table 5—Performance: Cost < $50; Demands ≥ 4/year

	Forward Stocked	Not Forward Stocked
Economical	1,646 ($709K)	9,956 (-$701K)
Not Economical	161 (-$30K)	12,826

TOTAL 5-YEAR NET SAVINGS: $679K

Adding a cost criterion of $50 prevents an excessive pipeline inventory of expensive items eliminating virtually all the beta-error. This resulted in a net savings of $679K over a 5-year period. Lowering the demand criterion generates additional savings:

Table 6—Performance: Cost < $50; Demands ≥ 2/year

	Forward Stocked	Not Forward Stocked
Economical	4,510 ($1.026M)	7,092 (-$384K)
Not Economical	507 (-$71K)	12,480

TOTAL 5-YEAR NET SAVINGS: $955K

Lowering the demand criterion to two or more demands significantly lowered the alpha-error capturing additional savings. The beta-error only slightly increased, and the total net savings was $955K over a 5-year period. This rule would stock 20% of the items demanded in the AOR (as compared to the 10% of items stocked under current DLA criteria).

Items Not Forward Stocked Due to Insufficient Storage Space

A total of 15,819 items met the criteria for a demand level at the using air base(s) but were unable to be forward stocked at the base due to insufficient storage space. Items that are economical to forward stock should be stored at DDKS until storage space is available at the forward bases. Items that are not economical should not be stored at DDKS and remain in CONUS.

Applying the new cost and demand criteria to the items yields the following:

Table 7—Performance: Cost < $50; Demands ≥ 2/year

	Forward Stocked	Not Forward Stocked
Economical	2,780 ($774K)	5,341 (-$286K)
Not Economical	246 (-$27K)	7,452

TOTAL 5-YEAR NET SAVINGS: $747K

A total of 3,026 items (19%) met the criteria to forward stock—of which 2,780 are economical. A total net savings of $747K results over a 5-year period. Savings can be increased if pipeline times are reduced. In particular, if the time from DDKS to the forward base is lowered to 5 days, the following performance is observed:

Table 8—Performance: Cost < $50; Demands ≥ 2/year (DDKS→Fwd Base = 5 Days)

	Forward Stocked	Not Forward Stocked
Economical	2,861 ($843K)	6,448 (-$337K)
Not Economical	145 (-$11K)	6,345

TOTAL 5-YEAR NET SAVINGS: $832K

Although the same amount of items is forward stocked, more items are economical with a shorter pipeline from DDKS. Savings is increased by approximately $85K ($832K-$747K) over a 5-year period. Furthermore, **stocking at DDKS is beneficial for all items not stocked at the using base *if the total pipeline time is less than the pipeline time direct from CONUS to the base***. Since these items are not stocked at the using base, any

pipeline time less than CONUS will reduce backorder time. As space becomes available, economical items can be selected for storage at the using base.

SBSS demand levels must be adjusted if forward stocked items have different order and ship times (O&ST) than items from CONUS. In the event of reduced forward pipeline times, ROP can be lowered for forward stocked items yielding a one-time savings. The resulting savings/costs associated with different forward pipeline times were computed assuming all 15,819 items were forward stocked. The results are in Table 9.

Table 9—O&ST Cost Differences (Items Not Forward Stocked)

Forward Leg (Days)	Direct Leg (Days)	Cost Difference
1	11	**-$2.6M**
3	11	**-$2.1M**
5	11	**-$1.5M**
7	11	**-$1.1M**
9	11	**-$481K**
11	11	**$0**
13	11	**$357K**
15	11	**$747K**

Therefore, if the forward pipeline is reduced to 5 days, there will be a one-time savings of $1.5M reduced supply levels at using bases, in addition to the $832K saved over a 5-year period under the proposed cost and demand criteria.

Items Currently Stocked at Forward Bases

Currently there are 566 items stocked at the using bases, of which, 529 are economical to forward stock. If the ship time from DDKS is reduced to 5 days, 537 items would be economical. SBSS demand levels would also require adjustments to their ROP levels yielding one-time savings. The cost differences for different forward O&ST are in Table 10.

Table 10—O&ST Cost Differences (Items Currently Stocked at Forward Bases)

Forward Leg (Days)	Direct Leg (Days)	Cost Difference
1	11	**-$21K**
3	11	**-$16K**
5	11	**-$12K**
7	11	**-$8K**
9	11	**-$4K**
11	11	**$0**
13	11	**$4K**
15	11	**$7K**

If ship time from DDKS is reduced to 5 days, a one-time savings of $12K would be realized.

Combat Air Force Logistical Support Center (CAF LSC) identified both the need to reduce the DLA-depot-to-using-base times and the need to track assets shipped from the forward depot, especially shipments for MICAP requirements. Without adequate tracking, delayed and lost shipments occur which create workload delay, replenishment times and potentially generate excesses (as other orders are placed to compensate for delayed shipments).

There is a "regional stock" alternative. For example, items can be stocked at DDKS without stocking at using bases. Although this would reduce inventory levels at the using bases it would ***increase backorders*** because of the added ship time from the DDKS to the using base. Therefore, this alternative is not recommended.

Throughout the analysis, it was assumed additional inventory storage costs are not incurred. Appendix A shows the savings achieved under storage costs. Applying the recommended forward stocking criteria still results in savings albeit at a lower amount. Savings under additional storage costs is maximized by lowering the cost criterion to $20. Appendix B conducts a sensitivity analysis on the CONUS-to-DDKS ship time increasing it to 60 days. Once again the recommended criteria results in lowered savings. Savings is maximized by reducing the cost criterion to $16.

Summary

An item is economically feasible to forward stock if the annual savings realized by reduced shipping costs exceeds the increased one-time, inventory investment costs within a five-year period. Performance of both the current DLA criteria and the new criteria was evaluated using three different data sets: all items with demands in the Middle Eastern theater, items not currently forward stocked due to limited storage space, and items currently stocked at using bases. ***The current DLA* criteria results in excessive costs by *forward stocking uneconomical* items**. ***By adding a unit-price threshold and lowering the demand threshold, about 20% of the items used in the AOR are economical to forward stock and would achieve a $747K, 5-year savings.*** A sensitivity analysis conducted by varying the CONUS-to-forward-storage and forward-storage-to-base legs indicated that savings are reduced as pipeline times increase. ***Forward storage can be attractive from a strictly, AF perspective (vice the DoD perspective that incurs increased pipeline inventory) and results in a one-time savings through lowered base levels. However, the pipeline time of the forward-storage-to-base leg must be lower than that of the direct leg, to achieve lower base levels***.

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Chapter 3

Conclusions and Recommendations

Conclusions

1. Current DLA forward stocking decision criteria (≥ 4 demands) only selects 10% of the items used in the AOR but ***increases cost by $675K*** over a 5-year period.

2. Using the following criteria to forward stock items reduces cost by $955K over a 5-year period and stocks 20% (5K) of items used in the AOR:

$$\text{Stock if} \quad \begin{cases} \text{Cost} < \$50 \\ \text{Demands} \geq 2 \end{cases}$$

3. It is economical to stock at the DDKS 19% (3K) of the inexpensive, DLA- managed items that are not currently stocked at the using bases due to storage limitations. If storage space becomes available for all these items, cost is reduced by $747K over a 5-year period.

4. Forward stocking may be beneficial to offset the availability of storage space at the AOR bases. However, to realize benefits, pipeline times for the DDKS to the AF-base must decrease and better in transit visibility is needed.

   - For items with insufficient storage to stock at the using base, if ship time from DDKS to the forward bases can be lowered to 5 days, the economical cost threshold would remain at $50, stock 19% of items and save an additional $85K ($832K-$747K) over a 5-year period.

     -- This would also reduce SBSS levels at the using Air bases by $1.5M.

Recommendations

1. Apply the proposed criteria to determine what items to forward stock at DDKS. (OPR: HQ DLA J-3734)

2. If pipeline times can be reduced, stock items that have insufficient storage at the using base. (OPR: HQ DLA J-3734)

3. Develop a process to update SBSS demand levels with forward DLA stocking O&ST. (OPR: HQ DLA J-3734 and MAF and CAF LSCs)

Expected Benefits

Forward stocking all AF-demanded items in the Middle Eastern AOR using the proposed criteria vice DLA's current criteria will potentially save the DoD approximately $955K over a 5-year time period. For items that cannot be stored at the using bases due to insufficient storage space, using the proposed criteria saves $747K over a 5-year period. Forward stocking may be beneficial to offset the availability of storage space at the AOR bases. However, pipeline times for DDKS to the AF-base must decrease and better in transit visibility is needed. The results of this study are particularly important with regard to the AF's continuing efforts in Agile Combat Support. It is critical that the AF support its AEF bases in ways that are not only effective but also efficient.

Appendix A

Storage Cost Sensitivity Analysis

In this appendix, a sensitivity analysis is conducted on storage cost. Throughout the analysis, it was assumed that inventory storage costs were subsumed in the DLA surcharge due to excess storage capacity at DDKS. If this assumption does not hold, forward stocked inventory incurs DLA's covered storage rate[2] of \$3.122 / $ft^3 \cdot yr$. Volume data is limited in SBSS with many National Stock Numbers (NSN) having omitted values. For NSNs in the Middle Eastern theater with existing volume data, the mean volume is .65 ft^3 and the median volume is .01ft^3. The large value of the mean relative to the median indicates that the distribution of volumes is positively skewed by a few items with relatively large volume. To select a default value for items with missing volumes, the median value of .01 ft^3 was used as this is representative of most items.

Combined Middle Eastern Theater Demands

When additional storage costs are incurred for items with demands in the Middle Eastern theater, the performance of the recommended forward storage criteria is:

Table 11—Performance: Cost < \$50; Demands ≥ 2/year (Storage Costs Incurred)

	Forward Stocked	Not Forward Stocked
Economical	4,264 (\$950K)	6,548 (-\$335K)
Not Economical	753 (-\$428K)	13,024

TOTAL SAVINGS: \$522K

Therefore, additional inventory storage costs reduce savings by \$433K (\$955K-\$522K). Lowering the cost threshold to \$20 maximizes total savings:

Table 12—Performance: Cost < \$20; Demands ≥ 2/year (Storage Costs Incurred)

	Forward Stocked	Not Forward Stocked
Economical	3,891 (\$860K)	6,922 (-\$426K)
Not Economical	320 (-\$303K)	13,456

TOTAL SAVINGS: \$557K

Under this modified rule, 4211 (17%) of items are forward stocked and savings increases by \$35K.

Items Not Forward Stocked Due to Insufficient Storage Space

For items not forward stocked due to insufficient storage space, the performance of the recommended criteria with storage costs is:

[2] Sanders, Darlene, Lt Col, USAF. HQ/DLA, electronic correspondence, 27 September 2006.

Table 13—Performance: Cost < $50; Demands ≥ 2/year (Storage Costs Incurred)

	Forward Stocked	Not Forward Stocked
Economical	2,627 ($702K)	4,937 (-$110K)
Not Economical	399 (-$284K)	7,856

TOTAL SAVINGS: $418K

Savings is reduced by $329K ($747K-418K) with additional storage costs. Only a negligible increase in savings occurs when the lower cost threshold of $20 is applied.

Table 14—Performance: Cost < $20; Demands ≥ 2/year (Storage Costs Incurred)

	Forward Stocked	Not Forward Stocked
Economical	2,351 ($634K)	5,214 (-$178K)
Not Economical	159 (-$216K)	8,095

TOTAL SAVINGS: $418K

The modified rule forward stocks 2,510 (16%) of items.

For both sets of items, the criteria recommended in this study results in savings under storage costs. As expected the resulting savings is reduced. However, savings can be increased by lowering the cost criterion to $20. This eliminates larger items which tend to have higher costs.

Appendix B

CONUS-to-DDKS Ship Time Sensitivity Analysis

A CONUS-to-DDKS ship time of 30 days was used throughout the analysis. A substantially longer ship time reduces savings as more pipeline inventory is required. In this section, CONUS-to-DDKS ship time is increased to 60 days and the resulting performance is observed for all items with demands in the Middle Eastern theater as well as items not forward stocked due to insufficient storage.

Combined Middle Eastern Theater Demands

For all items with demands in the Middle Eastern theater, a ship time to DDKS of 60 days results in the following performance of the recommended rule:

Table 15—Performance: Cost < $50; Demands ≥ 2/year (60 Day DDKS Ship Time)

	Forward Stocked	Not Forward Stocked
Economical	4,028 ($782K)	6,081 (-$292K)
Not Economical	989 (-$274K)	13,491

TOTAL SAVINGS: $509K

The 60-day ship time to DDKS reduces savings by $446K ($955K-$509K). Lowering the cost threshold to $16 maximizes total savings.

Table 16—Performance: Cost < $16; Demands ≥ 2/year (60 Day DDKS Ship Time)

	Forward Stocked	Not Forward Stocked
Economical	3,684 ($724K)	6,424 (-$351K)
Not Economical	286 (-$46K)	14,195

TOTAL SAVINGS: $678K

The modified rule forward stocks 3,970 (16%) of items.

Items Not Forward Stocked Due to Insufficient Storage Space

For items not forward stocked due to insufficient storage space, the performance of the recommended rule with a 60-day DDKS ship time is:

Table 17—Performance: Cost < $50; Demands ≥ 2/year (60 Day DDKS Ship Time)

	Forward Stocked	Not Forward Stocked
Economical	2,532 ($608K)	4,555 (-$220K)
Not Economical	494 (-$108K)	8,238

TOTAL SAVINGS: $500K

The increased pipeline time reduces savings by $247K ($747K-500K). Savings is slightly increased using the reduced cost threshold of $16.

Table 18—Performance: Cost < $16; Demands ≥ 2/year (60 Day DDKS Ship Time)

	Forward Stocked	Not Forward Stocked
Economical	2,259 ($557K)	4,828 (-$270K)
Not Economical	107 ($-15K)	8,625

TOTAL SAVINGS: $542K

The modified criteria stocks 2,366 (15%) of items.

If the ship time from CONUS to DDKS is increased to 60 days, savings is still achievable using the recommended criteria. As more inventory is required to fill the pipeline, savings is reduced. Lowering the cost criterion to $16 days maximizes savings under the increased ship times by eliminating costly items from the longer pipeline.

Appendix C

Derivation of Breakeven Time

This appendix provides the mathematical expression for breakeven time and cost. Let T_{XY} and C_{XY} be defined as the time (days) and cost ($) to ship an item from *X* to *Y*, respectively. For example, T_{CF} is the shipping time from CONUS to forward storage. Item cost ($/item) will be designated as C_I, and DDR_I and EOQ_I will be defined as daily demand rate (# demands/day) and economic order quantity (# items/shipment) for item *I*, respectively. The variable N^I_{BASES} represents the number of bases where item *I* is demanded. Storage cost at the forward location is C_{STG}. For brevity the direct route will be designated as *CB*, and the forward storage route will be designated as *CFB*. The investment costs (CB_{SETUP} and CFB_{SETUP}) are the costs associated with the sum of the following pipeline and safety level inventories:

Table 11—Inventory Investment Equations

	Pipeline Inventory Cost	Safety Level Inventory Cost
CB_{SETUP}	$DDR_I \cdot C_I \cdot t_{CB}$	$2 \cdot C_I \sqrt{3 \cdot DDR_I \cdot t_{CB}}$
CFB_{SETUP}	$DDR_I \cdot C_I \cdot (t_{CF}+t_{FB})$	$2 \cdot C_I \sqrt{3 \cdot DDR_I \cdot (t_{CF}+t_{FB})}$

Likewise, the annual costs (CB_{ANNUAL} and CFB_{ANNUAL}) are the sum of the shipping costs and new inventory purchase costs incurred each year. This is shown below:

Table 12—Annual Cost Equations

	Annual Shipping Cost	Annual Inventory Purchases
CB_{ANNUAL}	$\frac{DDR_I \cdot 365}{EOQ} \cdot N^I_{BASES} \cdot C_{CB}$	$DDR_I \cdot 365 \cdot C_I$
CFB_{ANNUAL}	$\frac{DDR_I \cdot 365}{EOQ}(C_{CF} + N^I_{BASES} \cdot C_{FB}) + C_{STG}$	$DDR_I \cdot 365 \cdot C_I$

The economic order quantity, *EOQ*, is computed based on an assumed order cost of $5.20 and a holding cost equal to 15% of item cost. Furthermore, it is bounded between 30 days and 365 days to avoid backorders. The expression for *EOQ* is

$EOQ_I = Round\left[\sqrt{\frac{2 \cdot 365 \cdot DDR \cdot 5.20}{.15C_I}}\right]$. The expression for storage cost is

$$C_{STG} = \left[Storage\ Cost \Big/ ft^3 \right] \underbrace{\left[\frac{EOQ_I}{2} + 2\sqrt{3 \cdot DDR \cdot t_{CF}} \right]}_{Average\ Inventory} \cdot Cube_I .$$

It is now possible to compute the breakeven time. The number of years to breakeven is attained by determining how many years it takes for the cumulative, annual cost savings to equal the one-time inventory investment cost increase:

$$\underbrace{(CB_{ANNUAL} - CFB_{ANNUAL})}_{Annual\ Shipping\ Savings} \cdot Years = \underbrace{CFB_{SETUP} - CB_{SETUP}}_{Increased\ Inventory\ Investment}$$

Solving this gives an expression for the breakeven time:

$$\Rightarrow Years = \frac{CFB_{SETUP} - CB_{SETUP}}{CB_{ANNUAL} - CFB_{ANNUAL}} .$$

Appendix D

Visual Basic Code

The following is the Visual Basic code used both to model the economic feasibility of forward stocking as well as evaluate the performance of cost-demand criteria pairs. The program inputs are the transportation costs and times as well as the storage cost. It applies these to a list of prospective items to compute their breakeven times and the savings if the items is forward stocked. It then tests a rectangular "grid" of cost-demand criteria pairs evaluating the performance of each.

```
Sub main()
   Dim i As Integer
   Dim k As Single
   Dim found As Boolean
   Dim headers As Range
   Dim EOQ, DDR, C_CB, C_CF, C_FB, t_CB, t_CF, t_FB, Diff_Setup_Cost, _
      Diff_Cont_Cost, BreakEven, threshold, n_alpha, n_beta, n_correct As Single

   'Read transportation costs and times and storage cost from "Settings" worksheet
   Sheets("SETTINGS").Select
   C_CB = Range("B3").Value
   C_CF = Range("B4").Value
   C_FB = Range("B5").Value
   t_CB = Range("B8").Value
   t_CF = Range("B9").Value
   t_FB = Range("B10").Value
   C_S = Range("B12").Value


   Sheets("DATA").Select
   Sheets("OUTPUT").Delete

   With Range("A1")
      Range(.Offset(0, 0), .Offset(0, 0).End(xlToRight)).Name = "Headers"
   End With

   N_Headers = Range("Headers").Columns.Count

   i = 0
   found = False


   'Find CRD in data
   Do Until found
      If Range("A1").Offset(0, i).Value = "CRD" Then
      With Range("A1")
         Range(.Offset(0, i), .Offset(0, i).End(xlDown)).Name = "DEMANDS"
```

```
    End With
        found = True
    End If

    i = i + 1
Loop

i = 0
found = False

'Find stock number in data
Do Until found
    If Range("A1").Offset(0, i).Value = "STOCK_NUMBER" Then
    With Range("A1")
        Range(.Offset(0, i), .Offset(0, i).End(xlDown)).Name = "STOCK_NUM"
    End With
        found = True
    End If

    i = i + 1
Loop

i = 0
found = False

'Find unit cost in data
Do Until found
    If Range("A1").Offset(0, i).Value = "UNIT_PRICE" Then
    With Range("A1")
        Range(.Offset(0, i), .Offset(0, i).End(xlDown)).Name = "UNIT_PRICE"
    End With
        found = True
    End If

    i = i + 1
Loop

i = 0
found = False

'Find nomenclature in data
Do Until found
    If Range("A1").Offset(0, i).Value = "NOMENCLATURE" Then
    With Range("A1")
        Range(.Offset(0, i), .Offset(0, i).End(xlDown)).Name = "UNIT_DESC"
    End With
        found = True
    End If

    i = i + 1
Loop

i = 0
found = False

'Find number of days in data
```

```
Do Until found
   If Range("A1").Offset(0, i).Value = "NUM_DAYS" Then
   With Range("A1")
      Range(.Offset(0, i), .Offset(0, i).End(xlDown)).Name = "DAYS"
   End With
      found = True
   End If

   i = i + 1
Loop

i = 0
found = False

'Find cube in data
Do Until found
   If Range("A1").Offset(0, i).Value = "CUBE" Then
   With Range("A1")
      Range(.Offset(0, i), .Offset(0, i).End(xlDown)).Name = "CUBES"
   End With
      found = True
   End If

   i = i + 1
Loop

i = 0
found = False

'Find number of bases item is demanded at in data
Do Until found
   If Range("A1").Offset(0, i).Value = "N_BASES" Then
   With Range("A1")
      Range(.Offset(0, i), .Offset(0, i).End(xlDown)).Name = "N_Bases"
   End With
      found = True
   End If

   i = i + 1
Loop

i = 0
found = False

'Find number of item demands in data
Do Until found
   If Range("A1").Offset(0, i).Value = "N_DEMANDS" Then
   With Range("A1")
      Range(.Offset(0, i), .Offset(0, i).End(xlDown)).Name = "N_DEMANDS"
   End With
      found = True
   End If

   i = i + 1
Loop
```

```
'Copy and paste each found column into new worksheet
Range("STOCK_NUM").Select
Selection.Copy

Sheets.Add.Name = "OUTPUT"
Range("A1").Select
ActiveSheet.Paste

Sheets("Data").Select
Range("UNIT_DESC").Select
Selection.Copy
Sheets("OUTPUT").Select
Range("B1").Select
ActiveSheet.Paste

Sheets("Data").Select
Range("CUBES").Select
Selection.Copy
Sheets("OUTPUT").Select
Range("C1").Select
ActiveSheet.Paste

Sheets("Data").Select
Range("UNIT_PRICE").Select
Selection.Copy
Sheets("OUTPUT").Select
Range("D1").Select
ActiveSheet.Paste

Sheets("Data").Select
n_demands = Range("DEMANDS").Rows.Count - 1
Range("DEMANDS").Select
Selection.Copy
Sheets("OUTPUT").Select
Range("E1").Select
ActiveSheet.Paste

Sheets("Data").Select
Range("DAYS").Select
Selection.Copy
Sheets("OUTPUT").Select
Range("F1").Select
Selection.PasteSpecial Paste:=xlPasteValues

Sheets("Data").Select
Range("N_Bases").Select
Selection.Copy
Sheets("OUTPUT").Select
Range("W1").Select
Selection.PasteSpecial Paste:=xlPasteValues

Sheets("Data").Select
Range("N_DEMANDS").Select
Selection.Copy
Sheets("OUTPUT").Select
```

```
Range("Y1").Select
Selection.PasteSpecial Paste:=xlPasteValues

'Place column headers in each pasted column in worksheet
Range("G1").Value = "DDR (# Items/Day)"
Range("H1").Value = "EOQ (# Items/Shipment)"
Range("I1").Value = "Fwd Stg: Pipeline Inv Cost ($)"
Range("J1").Value = "Direct: Pipeline Inv Cost ($)"
Range("K1").Value = "Fwd Stg: Safety Inv Cost ($)"
Range("L1").Value = "Direct: Safety Inv Cost ($)"
Range("M1").Value = "Fwd Stg: Ship Cost ($/Year)"
Range("N1").Value = "Direct: Ship Cost ($/Year)"
Range("O1").Value = "Difference Setup Costs ($)"
Range("P1").Value = "Difference Shipping Costs ($/Year)"
Range("Q1").Value = "Break Even Time (Years)"
Range("R1").Value = "# Shipments to Breakeven"
Range("S1").Value = "Savings"
Range("T1").Value = "Forward Stocked?"
Range("U1").Value = "Error"
Range("V1").Value = "Is Economical?"
Range("W1").Value = "Number Bases"
Range("Y1").Value = "Number Demands"

'Begin computing the breakeven time
k = 1
With Range("G1")
   Do While k <= n_demands
      If Not (.Offset(k, -2) = 0 Or .Offset(k, -1) = "" _
            Or .Offset(k, -1) = 0) Then
         Vol = .Offset(k, -4)
         C_I = .Offset(k, -3)
         DDR = .Offset(k, -2)
         N_Base = .Offset(k, 16)
         .Offset(k, 0) = DDR

         'Compute EOQ such that 30 <= EOQ <= 365
         If DDR > 0 Then
            EOQ = Sqr((2 * 365 * DDR * 5.2) / (0.15 * C_I))

            If EOQ < 30 And EOQ > 0 Then
               EOQ = 30
            ElseIf EOQ > 365 Then
               EOQ = 365
            End If

            .Offset(k, 1) = Round(EOQ, 0)

            'Compute & Round up Pipeline Inventory
            CFB_PipelineInv_Cost = Round(DDR * (t_CF + t_FB) + 0.5) * C_I
            CB_PipelineInv_Cost = Round(DDR * t_CB + 0.5) * C_I

            'Compute & Round up Safety Level Inventory
            CFB_SafetyInv_Cost = Round(2 * Sqr(3 * DDR * (t_CF + t_FB)) + 0.5) * C_I
            CB_SafetyInv_Cost = Round(2 * Sqr(3 * DDR * t_CB) + 0.5) * C_I

            'Compute & Round up Shipments
```

```
    CFB_Ship_Cost = Round(DDR * 365 / EOQ + 0.5) * (C_CF + N_Base * C_FB)
    CB_Ship_Cost = N_Base * Round(DDR * 365 / EOQ + 0.5) * C_CB

    'Compute Storage Cost
    If Vol > 0 Then 'If cube is not zero in database
       C_Stg = C_S * Vol * (EOQ / 2 + Round(2 * Sqr(3 * DDR * t_CF) + 0.5))
    Else 'Use default cube of .6 if cube is zero in database
       C_Stg = C_S * 0.01 * (EOQ / 2 + Round(2 * Sqr(3 * DDR * t_CF) + 0.5))
    End If

    'Compute difference in one-time costs between each route
    Diff_Setup_Cost = CFB_PipelineInv_Cost + CFB_SafetyInv_Cost - _
                CB_PipelineInv_Cost - CB_SafetyInv_Cost

    'Compute difference in annual costs between each route
    Diff_Cont_Cost = CB_Ship_Cost - CFB_Ship_Cost - C_Stg

    'Compute breakeven time
    BreakEven = Diff_Setup_Cost / Diff_Cont_Cost

    'Compute number of shipments to breakeven
    N_ShipmentsBrkEven = BreakEven * DDR * 365 / EOQ

    'Count how many items are economical to forward stock
    If Round(BreakEven, 2) < 5 And Round(BreakEven, 2) > 0 Then
       n_fwdstk = n_fwdstk + 1
       .Offset(k, 15) = "Economical"
    Else
       savings = 0
       n_notfwdstk = n_notfwdstk + 1
    End If

    'Compute savings of each item
    If Round(BreakEven, 2) > 0 Then 'If breakeven time is positive
       savings = (5 - BreakEven) * Diff_Cont_Cost
    Else 'If breakeven time is negative
       savings = 5 * Diff_Cont_Cost - Diff_Setup_Cost
    End If

    'Round all costs
    .Offset(k, 2) = Round(CFB_PipelineInv_Cost, 2)
    .Offset(k, 3) = Round(CB_PipelineInv_Cost, 2)
    .Offset(k, 4) = Round(CFB_SafetyInv_Cost, 2)
    .Offset(k, 5) = Round(CB_SafetyInv_Cost, 2)
    .Offset(k, 6) = Round(CFB_Ship_Cost, 2)
    .Offset(k, 7) = Round(CB_Ship_Cost, 2)
    .Offset(k, 8) = Round(Diff_Setup_Cost, 2)
    .Offset(k, 9) = Round(Diff_Cont_Cost, 2)
    .Offset(k, 10) = Round(BreakEven, 2)
    .Offset(k, 11) = Round(N_ShipmentsBrkEven + 0.5, 0)
    .Offset(k, 12) = Round(savings, 2)

    .Offset(k, 17) = C_Stg

  Else
    .Offset(k, 1) = 0
```

```
            End If
        End If

        k = k + 1
    Loop

End With

With Range("A1")
    N_NewHeaders = Range(.Offset(0, 0), .Offset(0, 0).End(xlToRight)).Columns.Count
    Range(.Offset(0, 0), .Offset(n_demands + 1, N_Headers)).Name = "RESULTS"
End With

Range("RESULTS").Sort key1:=Range("Q1"), order1:=xlAscending, _
    header:=xlYes

With Range("F1")
     n_demands = Range(.Offset(0, 11), .Offset(0, 11).End(xlDown)).Rows.Count
End With

'Begin threshold tests

Sheets("Performance").Delete
Sheets.Add.Name = "Performance"
Sheets("Output").Select

'Define grid of cost and demand criteria to test
init_cost = 15  'Starting cost
num_costs = 11  'Number cost points
d_cost = 1      'Cost increment
init_demand = 2 'Starting demand
num_demands = 1 'Number demand points
d_demand = 1    'Demand increment

'Initialize performance variables
k = 0
max_correct = 0
max_alpha = 0
max_beta = 0
max_cost = 0
max_demand = 0

max_savings = -10 ^ 9
max_alpha_sav = 0
max_beta_sav = 0
max_cost_sav = 0
max_demand_sav = 0

'Begin testing each cost/demand grid point
Do While k <= num_costs - 1
    cost_threshold = init_cost + k * d_cost
    j = 0
    demand = 0
    Do While j <= num_demands - 1
        demand_threshold = init_demand + j * d_demand
        n_alpha = 0
```

```
n_beta = 0
n_correct = 0
alpha_cost = 0
beta_cost = 0
savings = 0

i = 1

Sheets("output").Select
With Range("D1")

   'Alpha error case
   Do While i <= n_demands - 1 And Not (.Offset(i, 3) = 0)
      If ((.Offset(i, 0) >= cost_threshold) Or (.Offset(i, 21) < demand_threshold)) _
         And (.Offset(i, 13) < 5 And .Offset(i, 13) > 0) Then
         n_alpha = n_alpha + 1
         .Offset(i, 17) = "Alpha"
         alpha_cost = alpha_cost - .Offset(i, 15)

      'Beta error case
      ElseIf ((.Offset(i, 0) < cost_threshold) And (.Offset(i, 21) >= demand_threshold)) _
         And (.Offset(i, 13) > 5 Or .Offset(i, 13) <= 0) Then
         n_beta = n_beta + 1
         .Offset(i, 17) = "Beta"
         beta_cost = beta_cost + .Offset(i, 15)

      'Correct case with economical item
      ElseIf .Offset(i, 13) < 5 And .Offset(i, 13) > 0 Then
         .Offset(i, 17) = ""
         savings = savings + .Offset(i, 15)

      'Correct case with noneconomical item
      Else
         .Offset(i, 17) = ""
      End If
      .Offset(i, 25) = .Offset(i, 0)
      .Offset(i, 26) = .Offset(i, 21)
      .Offset(i, 27) = cost_threshold
      .Offset(i, 28) = demand_threshold

      If (.Offset(i, 0) >= cost_threshold) Or (.Offset(i, 21) < demand_threshold) Then
         .Offset(i, 16) = ""
      ElseIf (.Offset(i, 0) < cost_threshold) And (.Offset(i, 21) >= demand_threshold) Then
         .Offset(i, 16) = "FS"
      End If

      i = i + 1
   Loop

   'Compute number correct and alpha/beta errors
   n_correct = n_demands - n_alpha - n_beta - 1
   alpha = n_alpha / (n_demands - 1)
   beta = n_beta / (n_demands - 1)
   correct = n_correct / (n_demands - 1)

   'Compute total savings
```

```
            total_savings = savings + beta_cost

            'Update best performance criteria for most correct decisions
            If correct > max_correct Then
               max_correct = correct
               max_alpha = alpha
               max_beta = beta
               max_cost = cost_threshold
               max_demand = demand_threshold
            End If

            'Update best performance criteria for most savings
            If total_savings > max_savings Then
               max_savings = total_savings
               max_alpha_sav = alpha
               max_beta_sav = beta
               max_cost_sav = cost_threshold
               max_demand_sav = demand_threshold
            End If

         End With

         'Write grid point and associated performance data
         Sheets("Performance").Select
         With Range("A1")
            .Offset(k * num_demands * 11 + j * 11, 0) = "Cost Threshold"
            .Offset(k * num_demands * 11 + j * 11 + 1, 0) = "Demand Threshold"
            .Offset(k * num_demands * 11 + j * 11 + 2, 0) = "Alpha"
            .Offset(k * num_demands * 11 + j * 11 + 3, 0) = "Beta"
            .Offset(k * num_demands * 11 + j * 11 + 4, 0) = "Correct"
            .Offset(k * num_demands * 11 + j * 11 + 5, 0) = "Savings"
            .Offset(k * num_demands * 11 + j * 11 + 6, 0) = "Alpha Cost"
            .Offset(k * num_demands * 11 + j * 11 + 7, 0) = "Beta Cost"
            .Offset(k * num_demands * 11 + j * 11 + 8, 0) = "Total Savings"
            .Offset(k * num_demands * 11 + j * 11 + 9, 0) = "# FS"
            .Offset(k * num_demands * 11 + j * 11 + 10, 0) = "# Not FS"
            .Offset(k * num_demands * 11 + j * 11, 1) = cost_threshold
            .Offset(k * num_demands * 11 + j * 11 + 1, 1) = demand_threshold
            .Offset(k * num_demands * 11 + j * 11 + 2, 1) = alpha
            .Offset(k * num_demands * 11 + j * 11 + 3, 1) = beta
            .Offset(k * num_demands * 11 + j * 11 + 4, 1) = correct
            .Offset(k * num_demands * 11 + j * 11 + 5, 1) = savings
            .Offset(k * num_demands * 11 + j * 11 + 6, 1) = alpha_cost
            .Offset(k * num_demands * 11 + j * 11 + 7, 1) = beta_cost
            .Offset(k * num_demands * 11 + j * 11 + 8, 1) = total_savings
            .Offset(k * num_demands * 11 + j * 11 + 9, 1) = n_fwdstk - n_alpha + n_beta
            .Offset(k * num_demands * 11 + j * 11 + 10, 1) = n_demands - 1 - (n_fwdstk - n_alpha + n_beta)
            .Offset(k * num_demands * 11 + j * 11 + 2, 2) = n_alpha
            .Offset(k * num_demands * 11 + j * 11 + 3, 2) = n_beta
            .Offset(k * num_demands * 11 + j * 11 + 4, 2) = n_correct
         End With
         j = j + 1
      Loop

      k = k + 1
   Loop
```

```
    'Write cell headers for best performance criteria
    With Range("A1")
        .Offset(0, 4) = "Max Correct"
        .Offset(1, 4) = "Alpha"
        .Offset(2, 4) = "Beta"
        .Offset(3, 4) = "Cost Threshold"
        .Offset(4, 4) = "Demand Threshold"
        .Offset(0, 5) = max_correct
        .Offset(1, 5) = max_alpha
        .Offset(2, 5) = max_beta
        .Offset(3, 5) = max_cost
        .Offset(4, 5) = max_demand

        .Offset(0, 7) = "Max Savings"
        .Offset(1, 7) = "Alpha"
        .Offset(2, 7) = "Beta"
        .Offset(3, 7) = "Cost Threshold"
        .Offset(4, 7) = "Demand Threshold"
        .Offset(0, 8) = max_savings
        .Offset(1, 8) = max_alpha_sav
        .Offset(2, 8) = max_beta_sav
        .Offset(3, 8) = max_cost_sav
        .Offset(4, 8) = max_demand_sav

        .Offset(7, 4) = "Number Economical"
        .Offset(7, 5) = n_fwdstk
        .Offset(8, 4) = "Number Not Economical"
        .Offset(8, 5) = n_notfwdstk

    End With
End Sub
```

Glossary

AOR	Area of Responsibility
CAF LSC	Combat Air Force Logistical Support Center
CONUS	Continental United States
Cost Criteria	A threshold below which an item's cost must be to forward stock
Current DLA Criteria	Forward stock if item has ≥ 4 demands in a year
DDKS	Defense Distribution Depot Kuwait
DDR	Daily Demand Rate
Demand Criteria	A threshold above which an item's demand must be to forward stock
DLA	Defense Logistics Agency
DoD	Department of Defense
EOQ	Economic Order Quantity
Heuristic	A finite process that generally yields a good solution but does not guarantee optimality
NSN	National Stock Number
O&ST	Order and Ship Time
ROP	Reorder Point
SBSS	Standard Base Supply System

Distribution